FRONTAL WAVES ALONG THE KUROSHIO*

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ABSTRACT

Direct current measurements were conducted to investigate the characteristics of frontal waves propagating along the Kuroshio near the separation point from the western boundary. Waves propagating downstream detected as significant extended empirical orthogonal functions (EEOFs) are predominant over velocity fluctuations of periods shorter than 50 days, explaining 67 % of the total variance. The five apparent wave groups have periods of 7–18 days, wavelengths of 220–380 km, and phase velocities of 22–30 cm s^{-1}, respectively. Characteristics of the phase velocity of the observed waves are consistent with that of baroclinic instability waves, suggesting that the lower phase velocity along the Kuroshio current system than that along the Gulf Stream is caused by the lower background velocity.

REFEREMCE

Itoh and Sugimoto (2008)
JGR, **113**, C11020,
doi:10.1029/2007JC004682.

1. INTRODUCTION

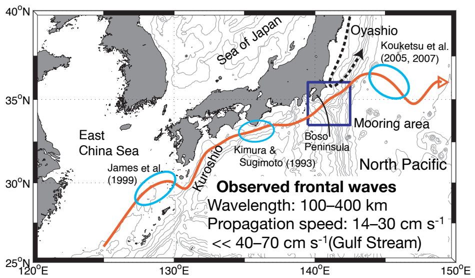

Fig. 1: Study area

Motivation

Insufficient understanding of characteristics and mechanism of frontal waves propagating downstream along the Kuroshio

2. DATA AND METHODS

2.1. Moorings

- ✦ 4 moorings equipped with 2 or 3 current meters (CMs)
- ✦ Off Boso peninsula (the separation point)
- ✦ From Apr. 2003 to Mar. 2004

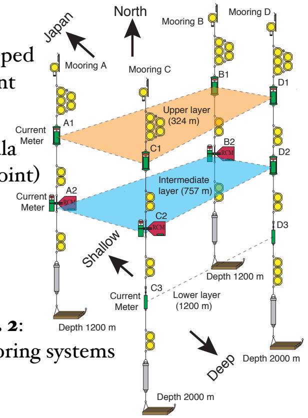

Fig. 2: Mooring systems

2.2. Extended EOF (EEOF) analysis

Covariance matrix of 612 time series
(51 (lags) × 6 (CMs) × 2 (u & v))

EEOFs representing spatio-temporal variability

3. FRONTAL WAVES

3.1 Mean field and EEOFs

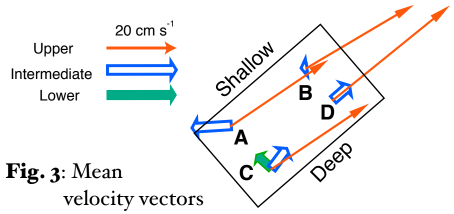

Fig. 3: Mean velocity vectors

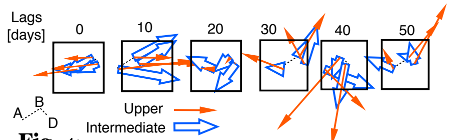

Fig. 4: An example of EEOF structure (EEOF1). Temporal variability is included in each function because multiple sets of lagged time series were considered in EEOF analysis.

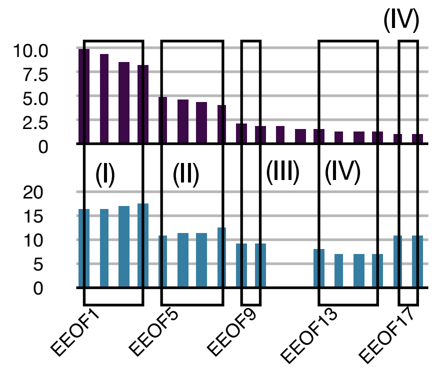

Fig. 5: (a) Variance [%] and (b) dominant period [days] of significant EEOFs. Groups of waves are shown with rectangles.

3.2 Wave characteristics

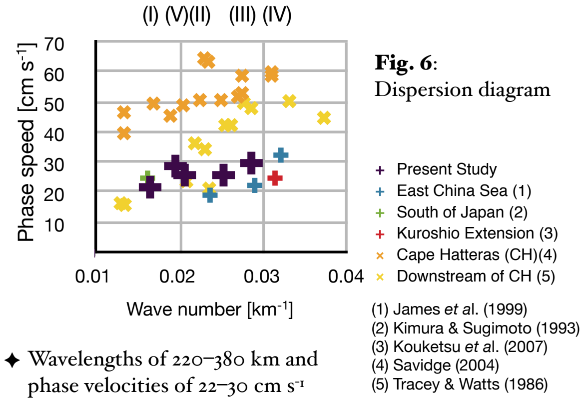

Fig. 6: Dispersion diagram

- ✦ Wavelengths of 220–380 km and phase velocities of 22–30 cm s^{-1}
- ✦ Lower phase velocity than those along the Gulf Stream
- ✦ Decreasing phase velocity with respect to wavelength

4. Two-layer model

Downstream propagation speed c_r of baroclinic instability wave in a two-layer fluid on an f-plane (after Pedlosky, 1987):

$$c_r = \frac{U_1 + U_2}{2} - \frac{(1-\gamma)(U_1 - U_2)}{2\gamma(K^2R^2 + \gamma + 1)}.$$

γ: Layer thickness ratio,
R: Internal radius of deformation
K: Wave number .

Characteristics of the phase speed

- ✓ Range between the mean velocities of the two layers.
- ✓ Decreasing trend with respect to wavelength
- → Consistent with the observed frontal waves

Estimation of phase speed using typical values

(U_1 = 50 cm s^{-1}, U_2 = 10 cm s^{-1}, γ = 0.2, R = 50 km)

- ✓ K = 0.017 km^{-1} ⇒ c_r = 21.7 cm s^{-1}
- ✓ K = 0.021 km^{-1} ⇒ c_r = 23.1 cm s^{-1}
- → Good agreement with Waves I (22 cm s^{-1}) and II (26 cm s^{-1}).

★ Higher background velocity of the Kurohsio than that of the Gulf Stream is suggested to cause the higher phase velocity.

*Full title: Characteristics of Frontal Waves Propagating Along the Kuroshio Near the Separation Point From the Western Boundary